Potential for Technology Innovation within the Internet2 Community: A Five-Year View

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One view of the landscape for the next 5 years

1. Broadly deployed Cyberinfrastructure
   - Campus
   - Pervasive (NEON, Earthscope)
   - NSF OCI (Dan Atkins – new director)
2. ‘Clean slate’ network architecture effort
   - GENI (NSF CISE)
3. International competitiveness
4. Growing general awareness of trust and privacy
5. ‘Reigniting’ tech sector?
6. Manageable optical infrastructure
   - Campus, regional, and national
Internet2 vs. Traditional Telecommunication Industry

Is the delta over t1 -> t3 value > cost?
EACH BRAIN REPRESENTS A LOT OF DATA

Comparisons must be made across several image sets

Volume sizes by resolution - brain = 1500 cm³

GB = Gigabyte = 10⁹
TB = Terabyte = 10¹²
PB = Petabyte = 10¹⁵

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<th>High res (2 B/p)</th>
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Internet2’s virtuous circle
Components

• Advanced networking
• Performance
• Security
• Middleware
Future Networking Challenges
Potential Model for Services and Capabilities to be Offered in Next Generation Higher Education Network Infrastructure

**Capabilities and Services:**
- Layer 0: Dark fiber
- Layer 1: Wavelengths
- Layer 2: GigE lightpaths (+ SONET circuits?)
- Layer 2.5: MPLS tunnels
- Layer 3: IPv4/v6

Source: ‘Group A’ Report, 2005
Fundamental Ideas

• The Internet uses a form of circuit switching at lower layers, although nowhere near as dynamic as the phone network.

• Shared packet networks are not very efficient in two cases:
  – when the network is overloaded, or
  – when the network requires quality of service.

• The phone network (which is an immediate reservation network) works well because all flows are small, ensuring economic network utilization.

• An immediate reservation network is unlikely to work for large data flows - inefficient utilization.
Fundamental Questions

• How will the architecture for future data networks evolve?
  – Is the architecture dependent on the application?
  – Should dynamic circuit switching techniques be part of the future architecture?
  – Are there hybrid approaches, ones that use both packet switching and circuit switching, that are candidates for future architectures?
  – Are the other techniques that should be a part of the future network

• GENI will be examining fundamental questions like the above
GENI (Global Environment for Network Innovation)
HOPI Project

• Hybrid Optical and Packet Infrastructure Project
• Examine a hybrid network architecture consisting of circuit switched and packet switched capabilities
• Two main ideas
  – Dynamic setup of lightpaths
  – The hybrid - integrating packet and circuit switched infrastructures
• Deploy national scale testbed
• Connect to other testbeds internationally
HOPI Node
Creating global-scale observatories

Photo: NASA
Performance
Vision: Performance

Information is …

• Available
  – People can find it (Discovery)
  – “Community of trust” allows access across administrative domain boundaries (AA)

• Ubiquitous
  – Widely deployed (Paths of interest covered)
  – Reliable (Consistently configured correctly)

• Valuable
  – Actionable (Analysis suggests course of action)
  – Automatable (Applications act on data)
Getting There: Build & Empower the Community

Decouple the Problem Space:
• Analysis and Visualization
• Performance Data Sharing
• Performance Data Generation

Grow the Footprint:
• Clean APIs between each layer
• Widespread deployment of measurement infrastructure
• Widespread deployment of common performance measurement tools
Roadmap

• Broad deployment
  – System measurement (perfSONAR)
  – End-user tools (NDT)
• Hybrid network evolution
• Generalized diagnostics
  – Performance
  – Security
  – Middleware
Security
Wide-aperture real-time security

- Potential to gather wide-area darknet data, etc, to more quickly identify bots and control points
- Potential to exchange between source and target domains real-time security event information, using new IETF standards, with privacy controls detailed security incident handling information
- The above, and other examples, depend on leveraging trust fabric for exchanging sensitive information in timely manner
Wireless and Roaming Security

- Two related areas:
  - network authentication of device/user/state
  - ability of roaming users to securely and transparently connect to a local host network.
- International efforts in roaming (eduRoam) driving an agenda
- Commercialization of software and adoption in open hot spots are possible
Charting longer-term approaches

• Finding, with industry, a venue to influence long-term directions
  – De-perimeterization, silent failures, complexity management, coupling new technology options such as optical bypass with existing security infrastructure
  – Coupling the outputs of GENI type efforts into the existing mesh
  – Federal policy on technology-related issues such as CALEA
GENI, trust and security

- Security, and trust to underpin security measures, are key GENI drivers
- Concepts such as trust-mediated transparency may preserve essential characteristics for future invention
Middleware – the next 5 years

• The marketplace around identity management and privilege management
• Completing the core middleware reference components
• Doing virtual organization management systems
  – Collaborative tools
• Organizational Workflow
  – Educore/“O OSS”
• Integrating middleware into the Grid computing environment
  – GridShib
A Richer Map
Identity Management

• Fundamental forces are at work
  – Federated enterprise efforts, most notably Shibboleth and SAML, WS-Fed, etc.
  – Personal “social” peer-peer technologies, most notably MS InfoCard and Higgins
  – Federal directives, such as HSPD-12, eAuthentication, and FDIC on-line banking guidelines
  – Privilege management growing in importance, driven by complexity and compliance
Identity Management, Higher Ed and the Corporate Sector

- How will the marketplace of being an identity service provider emerge—banks, ISP’s, etc.
- How will identity/privilege management applications develop? – privacy manager software (personal and enterprise), compliance audit tools, etc.
- VO type collaborations/partnerships across enterprises, across sectors, require both technical plumbing and shared apps.
A reference middleware architecture

- Some components are developed and maturing, e.g. identity management and federation, directories, authorization
- A few components need to be reworked and put into distributions, e.g. provisioning
- Some components are understood but not well-developed – connective middleware, DRM, workflow, etc.
- ~50% there
Components of Core Middleware
The Art of Federating
Federations Concept
Corporate Engagement Points

• Telecommunications
  – Advanced networking development

• Financial Sector
  – Common optical networking approach
  – Middleware

• Health Care Sector
  – Virtual Networks
  – Middleware

• Input needed!
Discussion

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